

WHAT IS CLAIMED IS:

- 1 1. A method for aging queued commands in a data storage device, comprising:
2 (a) queuing one or more commands for the data storage device; and
3 (b) selecting a next command from the queued commands based on a combination
4 of an expected access time (EAT) and an incentive term, wherein the incentive term
5 provides for selection of older ones of the queued commands that have larger EATs, instead
6 of younger ones of the queued commands that have smaller EATs.
- 1 2. The method of claim 1, wherein the combination of the expected access time
2 and the incentive term comprises subtracting the incentive term from the expected access
3 time.
- 1 3. The method of claim 1, wherein the incentive term is increased periodically.
- 1 4. The method of claim 1, wherein the incentive term begins at zero, remains at
2 zero for a number of queue sorts, and then increases continuously while the command is
3 queued.
- 1 5. The method of claim 1, wherein the incentive term's initial value and its rate
2 of increase are parameters that control service time and affect throughput in the data storage
3 device.

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6. The method of claim 1, wherein the expected access time for an n^{th} selection cycle and a q^{th} command is denoted as $EAT_{n,q}$:

$$\begin{aligned} EAT_{n,q} = & (SID_{n,q} - SID_{n-1}) \bmod SIDS_PER_REV \\ & + m * SIDS_PER_REV \\ & + p * SIDS_PER_REV \end{aligned}$$

where:

$SID_{n,q}$ is a rotational time for the q^{th} command at the n^{th} selection cycle,
 SID_{n-1} is a rotational time of a previously selected command,
 $SIDS_PER_REV$ is a total rotation time,
 m is an integer that is determined by a minimum seek time,
 p is a probability of a missed revolution,
 n is a selection cycle number, and
 N_q is the selection cycle number when the q^{th} command was queued.

7. The method of claim 1, wherein the incentive term for an n^{th} selection cycle and a q^{th} command is denoted as $AGE_EAT_{n,q}$:

$$AGE_EAT_{n,q} = AGE_RATE * [(n - N_q) - AGE_DELAY]$$

where:

AGE_DELAY is a selection cycle number indicating how long the incentive term remains at zero,
 AGE_RATE is a rate of increase for the incentive term,
 n is a selection cycle number, and
 N_q is the selection cycle number when the q^{th} command was queued.

8. The method of claim 7, wherein the $AGE_EAT_{n,q}$ is set to zero, until $(n - N_q)$ is greater than zero.

1 9. The method of claim 7, wherein the AGE_RATE and AGE_DELAY are set
2 to control how fast the incentive term increases and how many selection cycles to delay
3 before the incentive term's increases begin.

1 10. The method of claim 7, wherein the AGE_RATE and AGE_DELAY are set
2 to zero, when long service times are of no importance.

1 11. The method of claim 7, wherein the AGE_RATE is set to a small number
2 and AGE_DELAY is set to a large number, when only excessive service times are to be
3 avoided.

1 12. A data storage device, comprising:
2 a controller for queuing one or more commands for the data storage device, and for
3 selecting a next command from the queued commands based on a combination of an
4 expected access time (EAT) and an incentive term, wherein the incentive term provides for
5 selection of older ones of the queued commands that have larger EATs, instead of younger
6 ones of the queued commands that have smaller EATs.

1 13. The device of claim 12, wherein the combination of the expected access time
2 and the incentive term comprises subtracting the incentive term from the expected access
3 time.

1 14. The device of claim 12, wherein the incentive term is increased periodically.

1 15. The device of claim 12, wherein the incentive term begins at zero, remains at
2 zero for a number of queue sorts, and then increases continuously while the command is
3 queued.

1 16. The device of claim 12, wherein the incentive term's initial value and its rate
2 of increase are parameters that control service time and affect throughput in the data storage
3 device.

17. The device of claim 12, wherein the expected access time for an n^{th} selection cycle and a q^{th} command is denoted as $EAT_{n,q}$:

$$EAT_{n,q} = (SID_{n,q} - SID_{n-1}) \bmod SIDS_PER_REV \\ + m * SIDS_PER_REV \\ + p * SIDS_PER_REV$$

where:

$SID_{n,q}$ is a rotational time for the q^{th} command at the n^{th} selection cycle,
 SID_{n-1} is a rotational time of a previously selected command,
 $SIDS_PER_REV$ is a total rotation time,
 m is an integer that is determined by a minimum seek time,
 p is a probability of a missed revolution,
 n is a selection cycle number, and
 N_q is the selection cycle number when the q^{th} command was queued.

18. The device of claim 12, wherein the incentive term for an n^{th} selection cycle and a q^{th} command is denoted as $AGE_EAT_{n,q}$:

$$AGE_EAT_{n,q} = AGE_RATE * [(n - N_q) - AGE_DELAY]$$

where:

AGE_DELAY is a selection cycle number indicating how long the incentive term remains at zero,
 AGE_RATE is a rate of increase for the incentive term,
 n is a selection cycle number, and
 N_q is the selection cycle number when the q^{th} command was queued.

19. The device of claim 18, wherein the $AGE_EAT_{n,q}$ is set to zero, until $(n - N_q)$ is greater than zero.

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1 20. The device of claim 18, wherein the AGE_RATE and AGE_DELAY are set
2 to control how fast the incentive term increases and how many selection cycles to delay
3 before the incentive term's increases begin.

1 21. The device of claim 18, wherein the AGE_RATE and AGE_DELAY are set
2 to zero, when long service times are of no importance.

1 22. The device of claim 18, wherein the AGE_RATE is set to a small number
2 and AGE_DELAY is set to a large number, when only excessive service times are to be
3 avoided.

1 23. An article of manufacture embodying logic for aging queued commands in a
2 data storage device, comprising:

3 (a) queuing one or more commands for the data storage device; and
4 (b) selecting a next command from the queued commands based on a combination
5 of an expected access time (EAT) and an incentive term, wherein the incentive term
6 provides for selection of older ones of the queued commands that have larger EATs, instead
7 of younger ones of the queued commands that have smaller EATs.

1 24 The article of manufacture of claim 23, wherein the combination of the
2 expected access time and the incentive term comprises subtracting the incentive term from
3 the expected access time.

1 25. The article of manufacture of claim 23, wherein the incentive term is
2 increased periodically.

1 26. The article of manufacture of claim 23, wherein the incentive term begins at
2 zero, remains at zero for a number of queue sorts, and then increases continuously while the
3 command is queued.

1 27. The article of manufacture of claim 23, wherein the incentive term's initial
2 value and its rate of increase are parameters that control service time and affect throughput
3 in the data storage device.

1 28. The article of manufacture of claim 23, wherein the expected access time for
2 an n^{th} selection cycle and a q^{th} command is denoted as $EAT_{n,q}$;

$$\begin{aligned} EAT_{n,q} = & (SID_{n,q} - SID_{n-1}) \bmod SIDS_PER_REV \\ & + m * SIDS_PER_REV \\ & + p * SIDS_PER_REV \end{aligned}$$

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8 where:

9 $SID_{n,q}$ is a rotational time for the q^{th} command at the n^{th} selection cycle,

10 SID_{n-1} is a rotational time of a previously selected command,

11 $SIDS_PER_REV$ is a total rotation time,

12 m is an integer that is determined by a minimum seek time,

13 p is a probability of a missed revolution,

14 n is a selection cycle number, and

15 N_q is the selection cycle number when the q^{th} command was queued.

1 29. The article of manufacture of claim 23, wherein the incentive term for an n^{th}
2 selection cycle and a q^{th} command is denoted as $AGE_EAT_{n,q}$;

$$AGE_EAT_{n,q} = AGE_RATE * [(n - N_q) - AGE_DELAY]$$

5
6 where:

7 AGE_DELAY is a selection cycle number indicating how long the incentive term
8 remains at zero,

9 AGE_RATE is a rate of increase for the incentive term,

10 n is a selection cycle number, and

11 N_q is the selection cycle number when the q^{th} command was queued.

1 30. The article of manufacture of claim 29, wherein the AGE_EAT_{n,q} is set to
2 zero, until $(n - N_q)$ is greater than zero.

1 31. The article of manufacture of claim 29, wherein the AGE_RATE and
2 AGE_DELAY are set to control how fast the incentive term increases and how many
3 selection cycles to delay before the incentive term's increases begin.

1 32. The article of manufacture of claim 29, wherein the AGE_RATE and
2 AGE_DELAY are set to zero, when long service times are of no importance.

1 33. The article of manufacture of claim 29, wherein the AGE_RATE is set to a
2 small number and AGE_DELAY is set to a large number, when only excessive service times
3 are to be avoided.

1 34. A method for aging queued commands in a device, comprising:
2 (a) queuing one or more commands for the device; and
3 (b) selecting a next command from the queued commands based on a combination
4 of an expected access time (EAT) and an incentive term, wherein the incentive term
5 provides for selection of older ones of the queued commands that have larger EATs, instead
6 of younger ones of the queued commands that have smaller EATs.

1 35. The method of claim 34, wherein the combination of the expected access
2 time and the incentive term comprises subtracting the incentive term from the expected
3 access time.

1 36. The method of claim 34, wherein the incentive term is increased periodically.

1 37. The method of claim 34, wherein the incentive term begins at zero, remains
2 at zero for a number of queue sorts, and then increases continuously while the command is
3 queued.

1 38. The method of claim 34, wherein the incentive term's initial value and its rate
2 of increase are parameters that control service time and affect throughput in the data storage
3 device.

1 39. The method of claim 34, wherein the expected access time for an n^{th}
2 selection cycle and a q^{th} command is denoted as $EAT_{n,q}$;

$$\begin{aligned} EAT_{n,q} = & (SID_{n,q} - SID_{n-1}) \bmod SIDS_PER_REV \\ & + m * SIDS_PER_REV \\ & + p * SIDS_PER_REV \end{aligned}$$

7
8 where:

9 $SID_{n,q}$ is a rotational time for the q^{th} command at the n^{th} selection cycle,

10 SID_{n-1} is a rotational time of a previously selected command,

11 $SIDS_PER_REV$ is a total rotation time,

12 m is an integer that is determined by a minimum seek time,

13 p is a probability of a missed revolution,

14 n is a selection cycle number, and

15 N_q is the selection cycle number when the q^{th} command was queued.

1 40. The method of claim 34, wherein the incentive term for an n^{th} selection cycle
2 and a q^{th} command is denoted as $AGE_EAT_{n,q}$;

$$AGE_EAT_{n,q} = AGE_RATE * [(n - N_q) - AGE_DELAY]$$

5
6 where:

7 AGE_DELAY is a selection cycle number indicating how long the incentive term
8 remains at zero,

9 AGE_RATE is a rate of increase for the incentive term,

10 n is a selection cycle number, and

11 N_q is the selection cycle number when the q^{th} command was queued.

1 41. The method of claim 40, wherein the AGE_EAT_{n,q} is set to zero, until (n -
2 N_q) is greater than zero.

1 42. The method of claim 40, wherein the AGE_RATE and AGE_DELAY are
2 set to control how fast the incentive term increases and how many selection cycles to delay
3 before the incentive term's increases begin.

1 43. The method of claim 40, wherein the AGE_RATE and AGE_DELAY are
2 set to zero, when long service times are of no importance.

1 44. The method of claim 40, wherein the AGE_RATE is set to a small number
2 and AGE_DELAY is set to a large number, when only excessive service times are to be
3 avoided.

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